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ABSTRACT

The purpose of this study was to examine the division procedures of preschool children to determine whether such procedures involved one-to-one correspondence. Large and small numerosity trials were included so that the amount of effort and ease of using other procedures would vary. Odd and even number trials were included to determine whether children actually knew what the procedures they used implied about relative numerosity. Subjects were 20 four-year-olds and 20 five-year-olds, with equal numbers of males and females in each group. On each trial of the division task, children were shown two cookie monsters and a pile of round cardboard cookies and were asked to give both cookie monsters the same number of cookies to eat. When children finished distributing the cookies, they were asked whether the two cookie monsters had the same number of cookies. Children were videotaped while performing the task. Trials were scored as correct if the child had an equal number of cookies on each monster's plate after using all the cookies on the even number trials or all but one cookie on the odd. Findings indicated that although preschool children used one-to-one correspondence strategies to solve division problems, their use of such strategies was not consistent. Children used more strategies on large numerosity and odd number trials than on other trials. (RH)

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Preschool Children's Informal Division Concepts

Two recent studies suggest that concepts concerning division should be added to the list of mathematical concepts that begin to develop prior to formal training in school. Klein and Langer (1985) presented young children with objects to divide into two groups. They found that by 2 1/2 children could construct two equal groups by using an alternating correspondence procedure. First, they put some objects in one group and then placed the same number of objects in the other group. Miller (1984) gave 3- to 9-year-olds a division task which involved dividing objects into two, three, or four equal groups. The majority of children used the alternating correspondence procedure described above, except that they placed one object in a group at a time.

Klein and Langer (1985) and Miller (1985) have demonstrated that children use division procedures that may involve the principle of one-to-one correspondence. The purpose of this study was to further examine the division procedures of preschool children and to determine whether these procedures involve one-to-one correspondence. Fuson & Hall (1983) have suggested that the probability that a correspondence procedure will be used to make relative numerosity judgements is influenced by the child's motivation to be correct, the amount of effort involved, and the ease of using other procedures. Therefore, large numerosity (10 and 11) and small numerosity (3 and 4) trials were included so that the amount of effort and

ease of using other procedures would vary. Odd and even number trials were included as a check to determine whether children actually knew what the procedures they used implied about relative numerosity.

Method

Subjects

Twenty four-year-olds (X = 4-6) and twenty five-year-olds (X = 5-4) participated in the study. An equal number of males and females were included in each age group.

Procedure

Each child was given a number conservation task, an addition and subtraction task, and a division task. Only the division task will be discussed.

The division task was composed of the trials listed in Table 1. On each trial children were shown two cookie monsters and a pile of round cardboard cookies, randomly arranged, and asked to give both cookie monsters the same number of cookies to eat. The cookies were placed on round cardboard "plates". When the children finished they were asked whether the two cookie monsters had the same number to eat. Children were videotaped while performing the task.

Table 1

Trials in the Division Task

Numerosity	Total number of cookies	Number of trials
Small	3	2
	4	2
Large	11	2
	10	2

Results

The division trials were scored as correct if the child had an equal number of cookies on each plate, after using all the cookies on the even number trials, or using all but one cookie on the odd number trials. The percentage of children correct on the various division trials is in Table 2.

Table 2
Percent Correct on Each Type of Division Trial

Age	Trial			
	3	4	10	11
4	65%	98%	83%	38%
5	75%	92%	88%	48%

An analysis of variance on these data revealed that children found the odd number trials more difficult regardless of numerosity. Post hoc analyses of the main effect for trial, $F(3,114) = 21.5$, $p < .001$, demonstrated that the 11 cookie trials were the hardest, followed by the 3 cookie trials. Performance on the 10 and 4 cookie trials was not significantly different (Newman Keuls tests, $p < .05$).

Failures on the 3 and 11 cookie trials had different causes. On the 3 cookie trial most children who were incorrect understood that the two arrays were not the same, but they did not know how to make them the same. These children either did not think of using subtraction or thought they had to put all the cookies on the plates. On the 11 cookie trial children who were incorrect said both arrays had the same when in fact they did not. This is demonstrated in Table 3.

Table 3
Frequency of Incorrect Responses on the 3 and 11 Cookie Trials

Type of Response	Age	Trial 3	Trial 11
Two arrrays are not the same, can't fix them	4	86%	25%
	5	70%	25%
Two arrays are the same (two arrays are not the same)	4	14%	76%
	5	0	65%

These data suggest that on the 11 cookie trials children distributed the cookies until it looked like both arrays had the same number of cookies. Notice that this approach is more likely to lead to success on even numerosity trials, such as

the 10 cookie trial, than on the odd numerosity trials. This prediction is supported by the percent correct data.

The particular strategies children use to divide the cookies were also examined. In these analyses only the performance of children who were correct was examined. The strategies children used are listed in Table 4.

Table 4
Types of Strategies Used in the Division Task

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one-one correspondence--put one cookie on a plate and one cookie on the other plate.

many-many correspondence--put some on one plate and the same number on the other plate

subtraction--remove one or more cookies from a plate

counting--any form of counting

miscellaneous distribution--put some on one plate and then put a different number on the other plate

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The percentage of children using the various strategies is listed in Tables 5 and 6.

Table 5
Percentage of Children Using Division Strategies on the 3 and 4 Cookie Trials

Strategy	Age	Trial			
		3 cookies (Trial 1)	3 cookies (Trial 2)	4 cookies (Trial 1)	4 cookies (Trial 2)
one-one	4	69% (N=13)	62% (N=13)	35% (N=20)	37% (N=19)
	5	66% (N=15)	77% (N=15)	26% (N=19)	32% (N=19)
many-many	4	---	---	55%	58%
	5	---	---	63%	63%
counting	4	8%	8%	5%	11%
	5	20%	13%	11%	5%
miscellaneous distribution	4	15%	31%	5%	0
	5	20%	7%	0	0
subtraction	4	77%	62%	0	5%
	5	53%	40%	0	0

On the small numerosity trials there are limitations on the types of possible strategies. For example, on the 3 cookie trial many-to-many correspondence is not possible. On these trials children used one-one correspondence and subtraction strategies most frequently. On the 4 cookie trials children used one-one correspondence or many-many correspondence. The majority of children, 83%, used only one strategy on the 4 cookie trials.

Table 6
Percentage of Children Using Division Strategies on the 10 and 11 Cookie Trials

		Trial			
Strategy	Age	10 cookies (Trial 1)	10 cookies (Trial 2)	11 cookies (Trial 1)	11 cookies (Trial 2)
one-one	4	58% (N=19)	50% (N=16)	38% (N=8)	29% (N=7)
	5	61% (N=18)	75% (N=16)	50% (N=10)	56% (N=9)
many-many	4	37%	44%	25%	14%
	5	44%	19%	40%	22%
counting	4	26%	38%	50%	57%
	5	22%	44%	60%	56%
miscellaneous distribution	4	26%	38%	88%*	71%**
	5	28%	19%	40%*	22%**
subtraction	4	26%	31%	100%***	86%
	5	5%	6%	50%***	44%

*a significant decrease ($z = 2.07$, $p < .05$)
**a significant decrease, ($z = 1.96$, $p < .05$)
***a significant decrease, ($z = 2.35$, $p < .05$)

Children used a wider variety of strategies on the 10 and 11 cookie trials than on the 3 and 4 cookie trials. The only developmental difference as on the 11 cookie trials, 4-year-olds used miscellaneous distribution and subtraction more than 5-year-olds. Four-year-olds more often reached a correct solution by a process of distributing all the cookies and then making adjustments, while the 5-year-olds were more likely to stop once each plate had 5 cookies.

Discussion

The results of this study are consistent with those of Miller (1984) and Klein & Langer (1985), preschool children do use one-to-one correspondence strategies to solve division problems. However, their use of these strategies is not consistent. Children used more strategies on the large numerosity trials and odd number trials. Their use of several strategies suggests that they have problems in applying a strategy so they switch to another or that they do not understand that some of the strategies are more effective becasue they provide quantitative information. Both of these alternatives suggest that the use of one-to-one correspondence strategies is not a reliable way for a 4- or 5-year-old to obtain quantitative information.

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